§7. Development of Power Monitor for ECH

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Electron cyclotron heating is one for the main methods to produce and heat plasmas in the Large Helical Device (LHD). ECH system has been operated during fourth cycle experimental campaign with 5 sets of gyrotron and transmission system. Two 82.7 GHz and three 168 GHz gyrotrons are operated routinely.

The reliable real time monitors of the state of the gyrotron oscillation and the transmission power are necessary for the safety operation of the gyrotrons as well as for the experimental data analysis. We developed real time 84GHz power monitor in order to measure the output/transmission power and a mode jump [1]. We have designed and produced E- and H-plane power monitor by setting the electric field direction of the attached fundamental waveguide to be perpendicular and parallel to the reflecting mirror surface. We checked the performance by setting of this monitor between the gyrotron MOU output and the calorimetric load. Figure 1 shows the correspondence of the gyrotron output power measured by the calorimetric load and the monitor output voltage. The scales on the right hand side show the calibrated detected power. The coupling coefficients measured by this method were 66 and 70 dB for E and H-plane, respectively. These E- and H- monitors are built in a single reflecting mirror to get both polarizations at the same position simultaneously. We installed this power monitor in a transmission line and used it during the fourth cycle experimental campaign. This monitor offered the signal routinely through the campaign. It is noted that one of these monitors is set and worked without any trouble in the line that transmitted the power above 300 kW. Main results from the fourth cycle experimental campaign for this type of power monitor can be summarized as follows.

- The transmission results of this power monitor are 300kW/2s.
- This power monitor was able to detect a mode jump signal. Figure 2 is an example of oscilloscope trace of the power monitor when the mode jump of the gyrotron oscillation is detected.
- The output from this power monitor changed accordingly when the polarizer installed in the upstream toward the gyrotron is rotated.

We can keep the safety operation of the gyrotron and deliver precise injected power information for the data analysis by this monitor.

We also tried to manufacture this type of power monitor for 168GHz. Since the size of the waveguide built in the monitor is half of that for 84GHz and is approaching the limit of normal machining method, we adopted the electric discharge machining method for manufacturing. We already got preliminary results with 168 GHz monitor and the optimization of the coupling coefficient is underway.

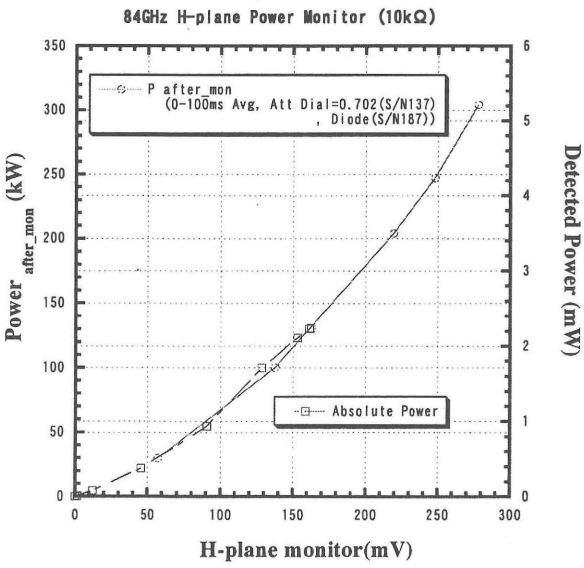
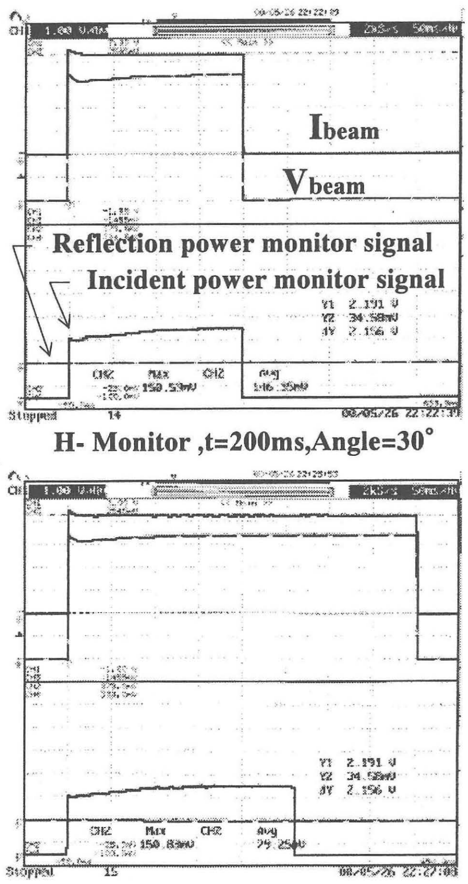


Fig.1. Low power and high power test result of H-plane monitor.



Mode jump (H- Monitor ,t=260ms,Angle=30)

Fig.2. The power monitor signals in an experiment and the gyrotron beam voltage and current.

Reference

(1) Kobayashi, S. et al., NIFS Annual Report (1999-2000), p.124